Will GLAST Identify Dark Matter?

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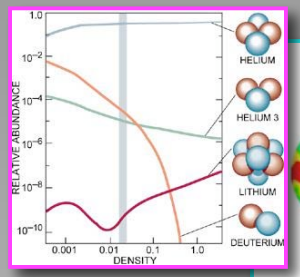
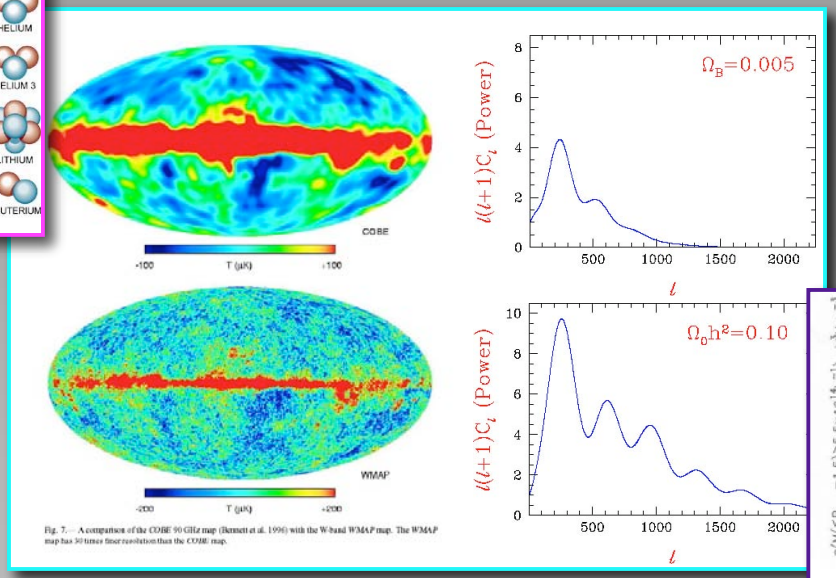
astro-ph/0610731

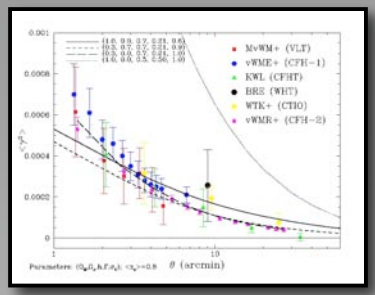
The Evidence for Dark Matter

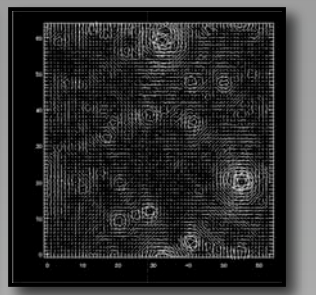
Over the past decade, growing evidence from many different scales and redshifts:

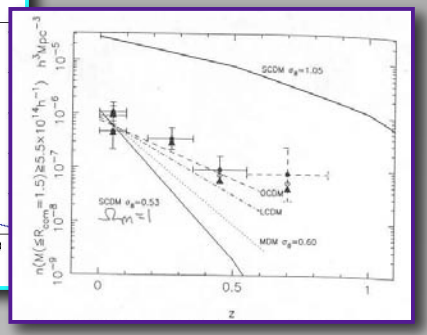
nucleosynthesis ; CMB ; local structure / cluster number counts / weak lensing

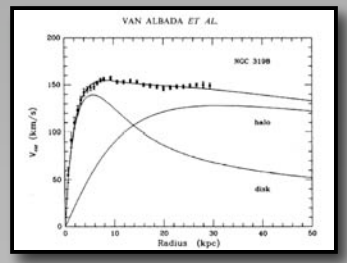






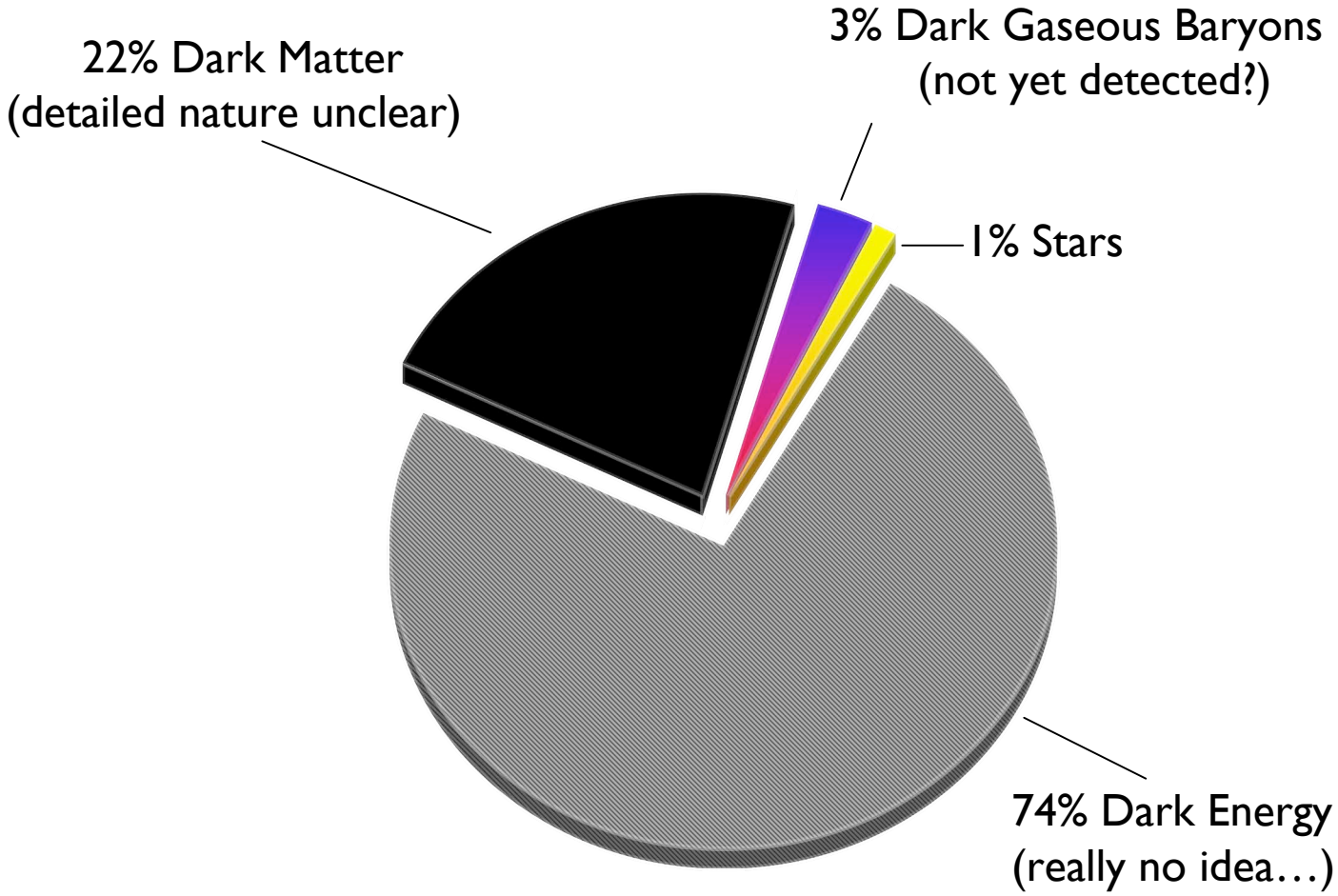






Ω_b	<<	Ω_m	<<	Ω_T
$0.0224h^{-2}$ +/- 0.0009	<<	$0.135h^{-2}$ +/- 0.009	<<	1.0
0.04 +/- 5%		0.27 +/- 10%		1.0

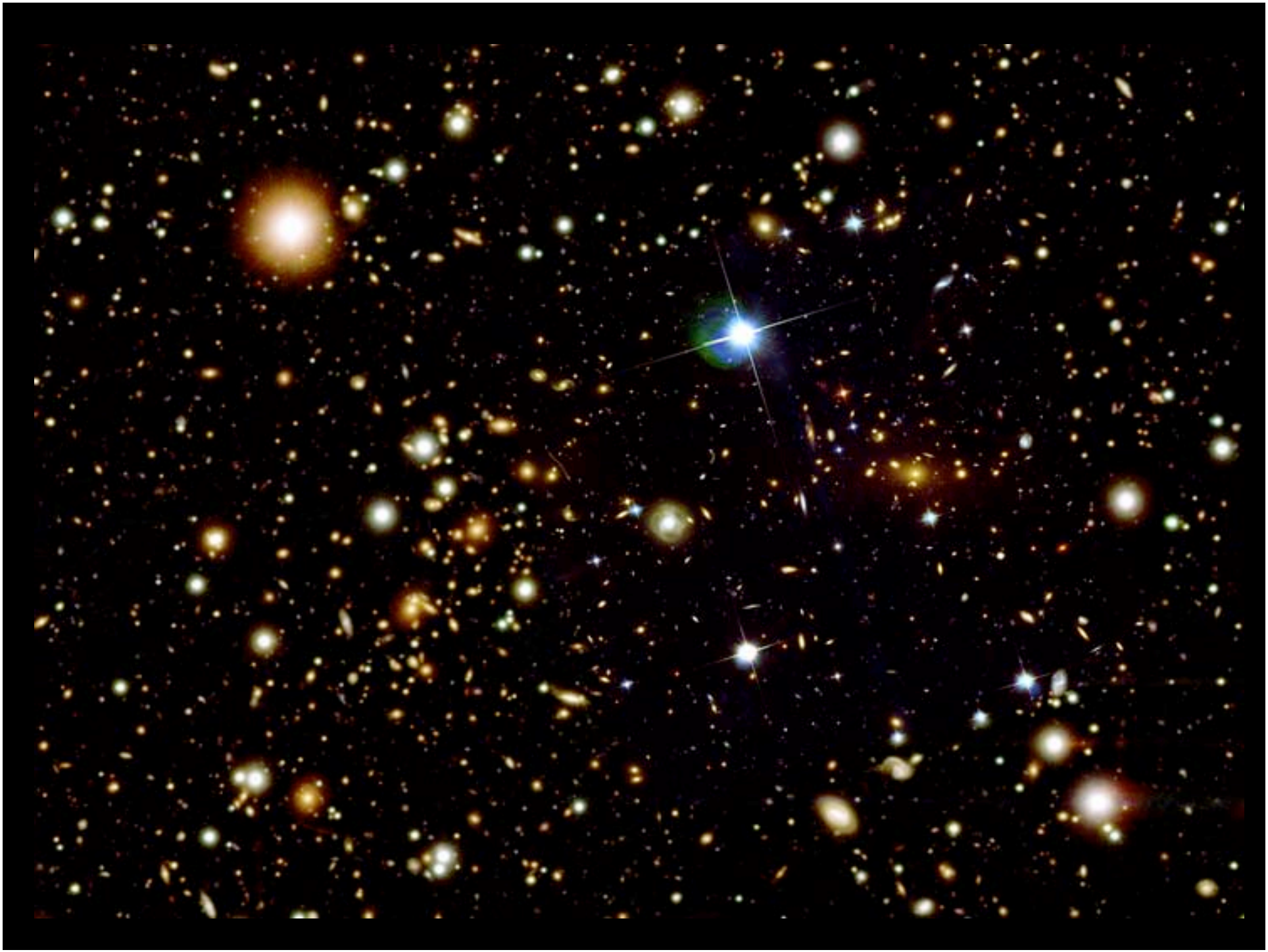
Summary:
The Composition of the Universe (first quarter, 2007)

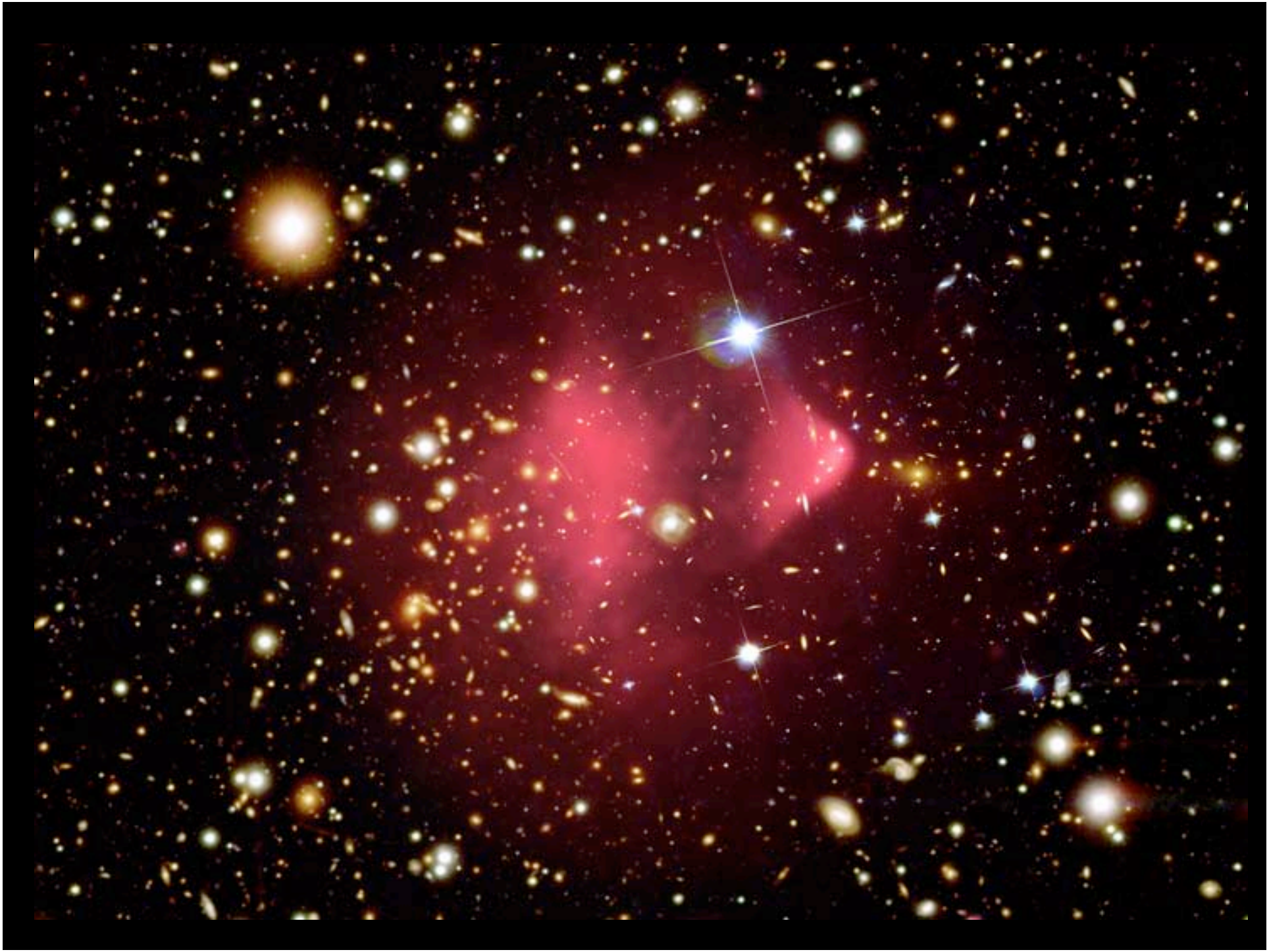


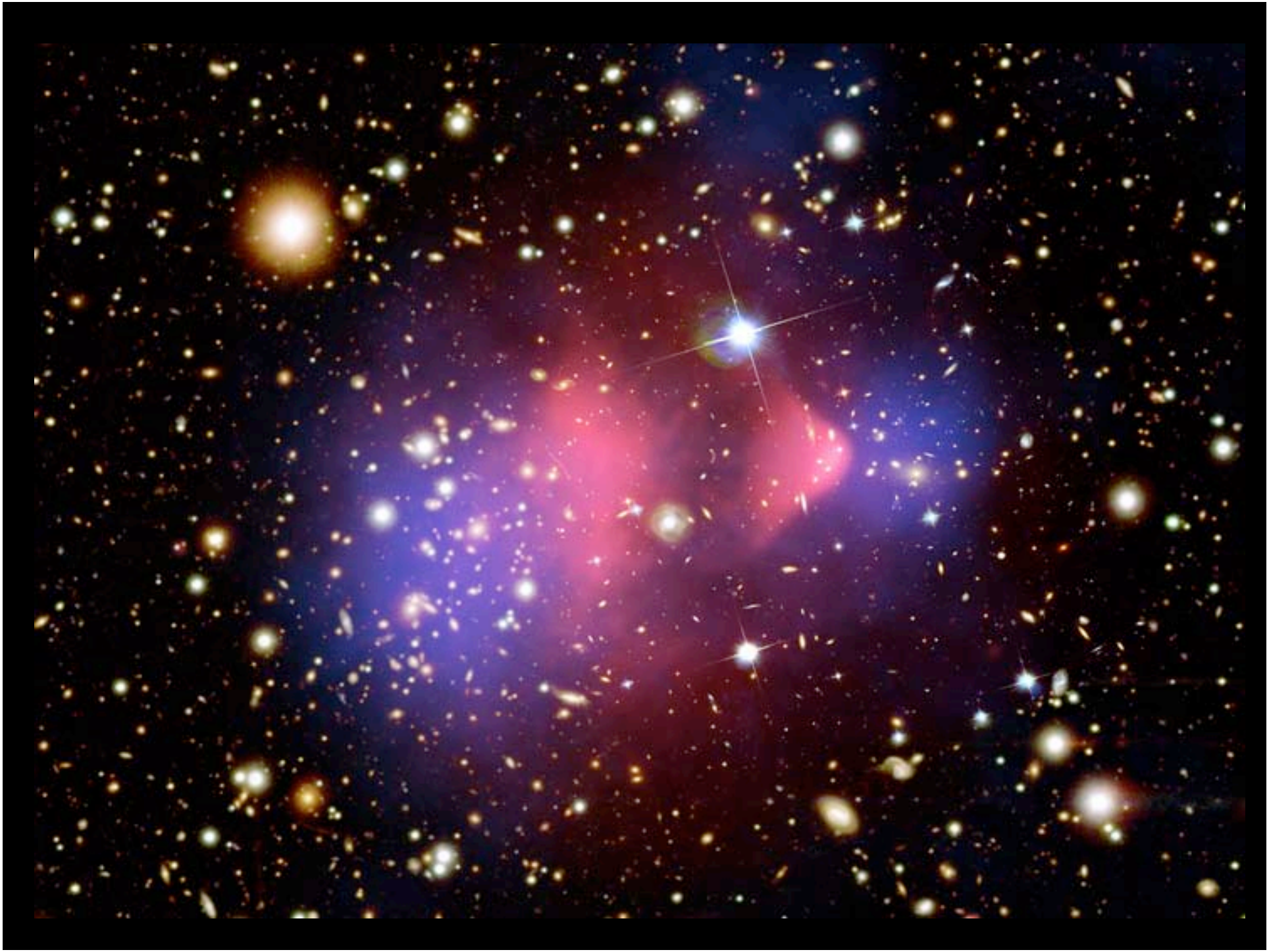
But is it CDM…

1E 0657-56 : A smoking Bullet?

Bullet Cluster - Chandra/HST press release

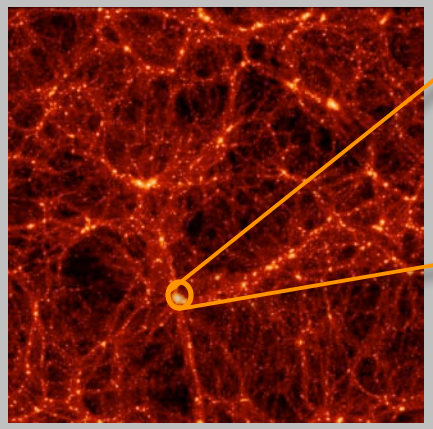




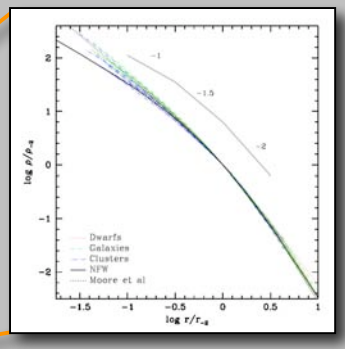


Implications of CDM:

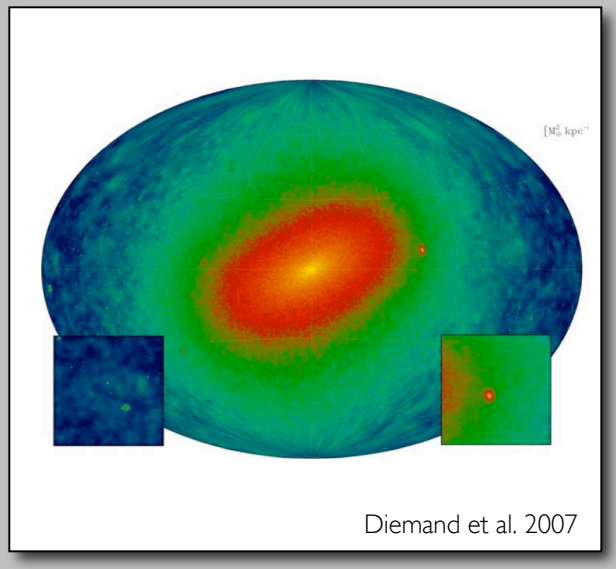
Structure forms ellipsoidal `haloes' with cuspy (~NFW) density profiles; profiles imply large rates for 2-body processes in halo centres ⇒ for WIMPs, annihilation rates can be interesting.



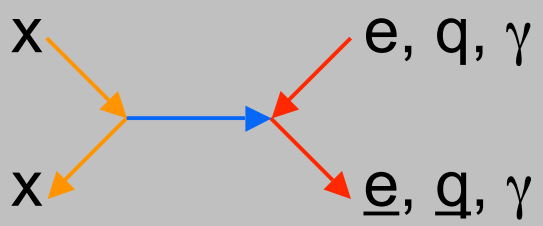
The Virgo consortium



Navarro et al. 2004

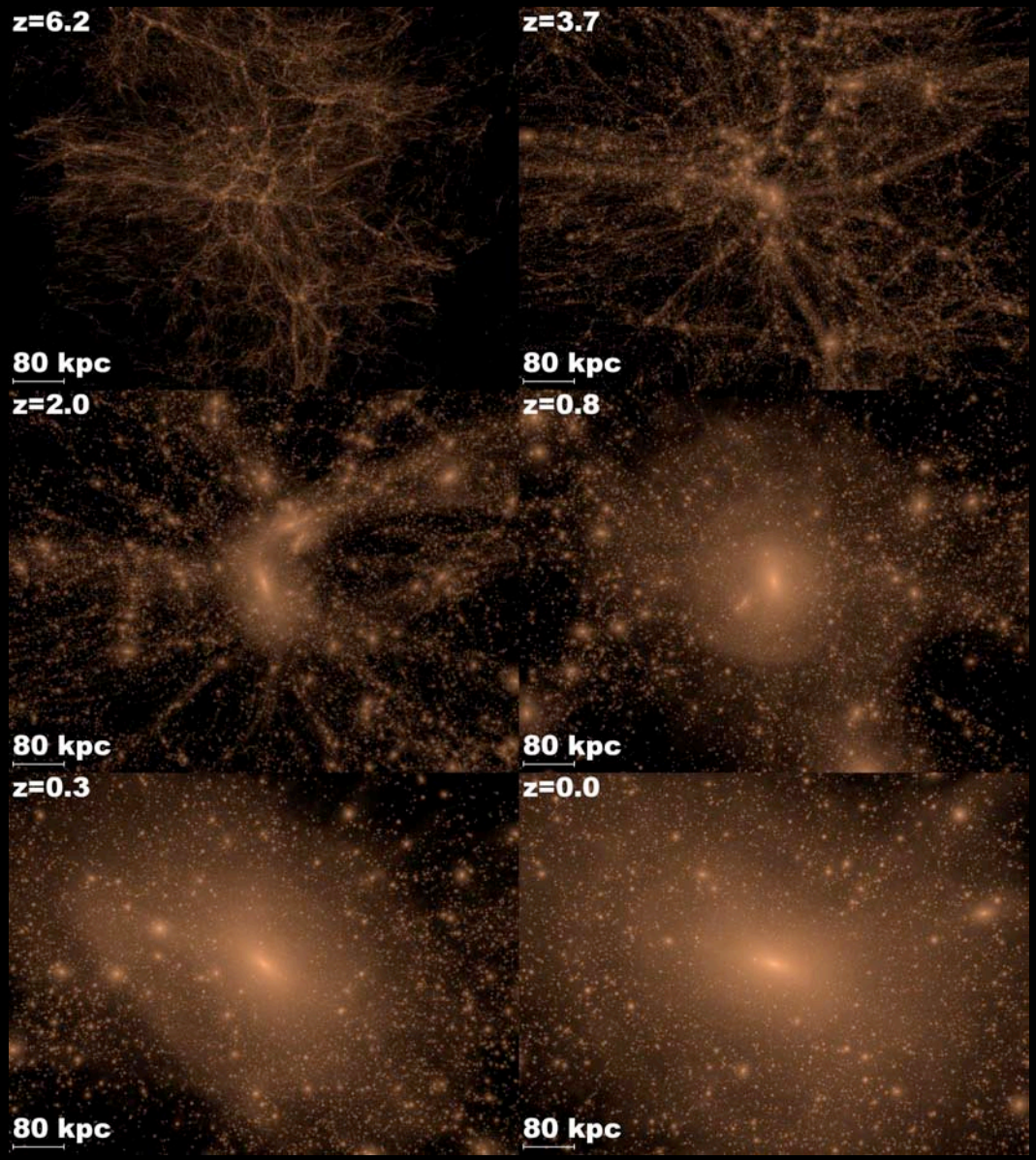


Diemand et al. 2007



Haloes grow hierarchically, incorporating debris - dense lumps and tidal streams - from earlier phases of structure formation.

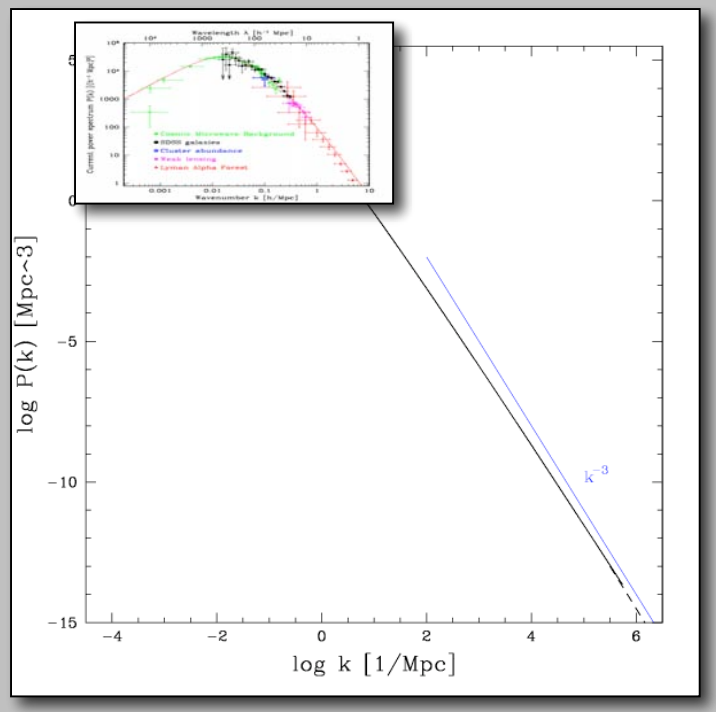
Not clear where this hierarchy ends as one goes down in mass/back in redshift…

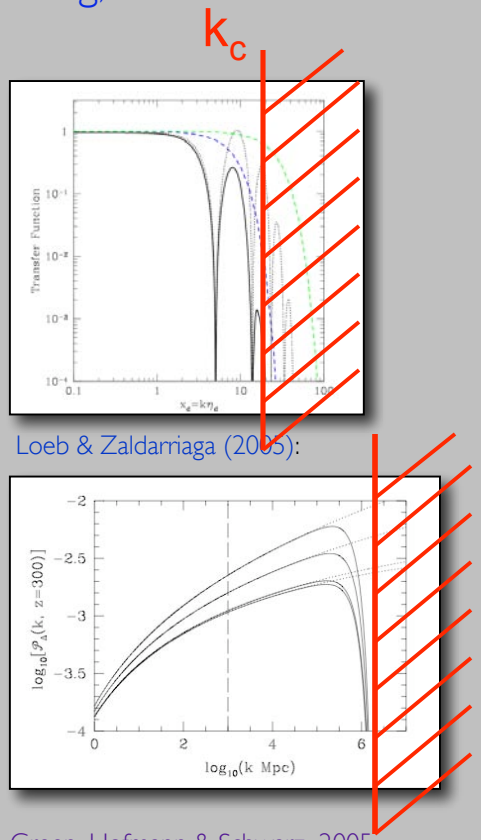


Via Lactea - Diemand, Kuhlen, Madau)

Implications of CDM:

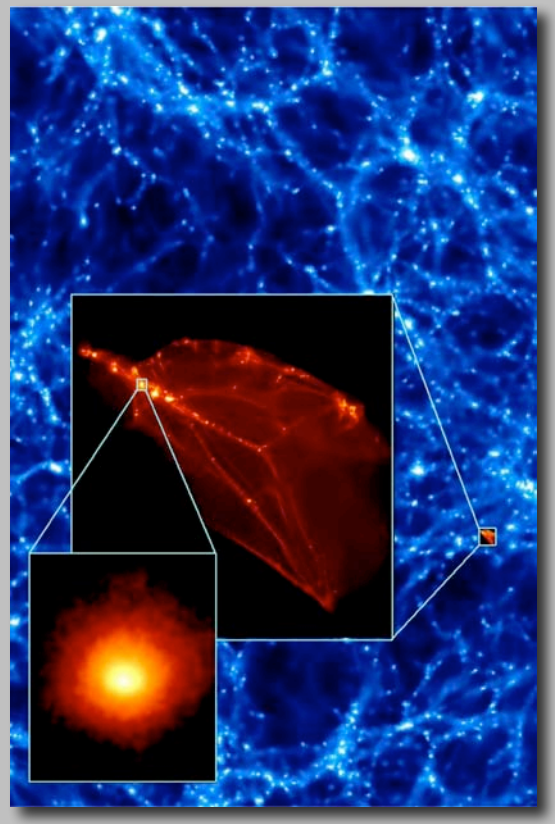
Structure formation does not track star formation; the smallest dark matter structures can form before last scattering, on scales much smaller than those of dwarf galaxies.





Loeb & Zaldarriaga (2005):

Green, Hofmann & Schwarz 2005



Diemand et al. 2005

Profumo et al 2006 : $M_c = 10^{-4} - 10^{-12}\ M_\odot$

Structure of the local neighbourhood:

(Some controversy about this - cf. astro-ph/0501589, 0502049, 0502213, 0508215, 0604142, 0608580)

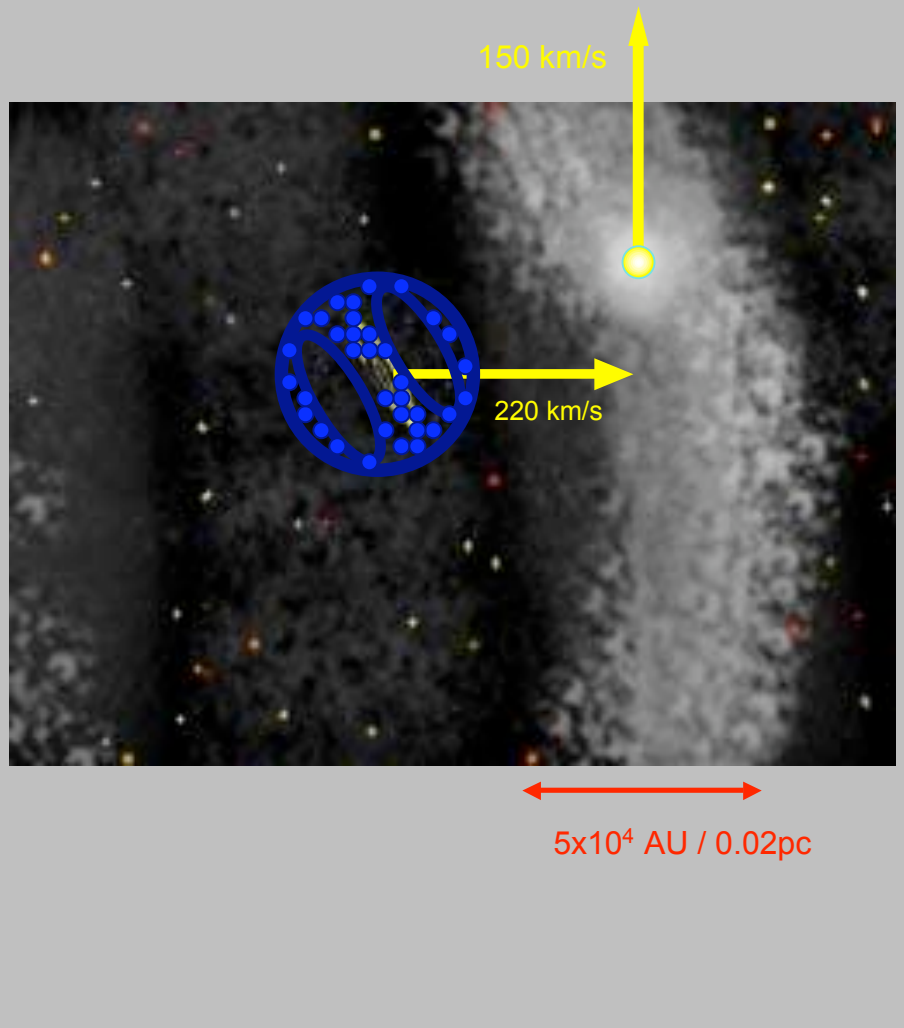
In local solar neighbourhood, complex structure of smooth mass, old mixed streams, surviving nuclei and dense recent streams

Filling factor for streams may be close to 1, producing constant variations in direct detection rate on timescales of 100 years

Even in mixed material, strong anisotropy in plane vs. out of plane

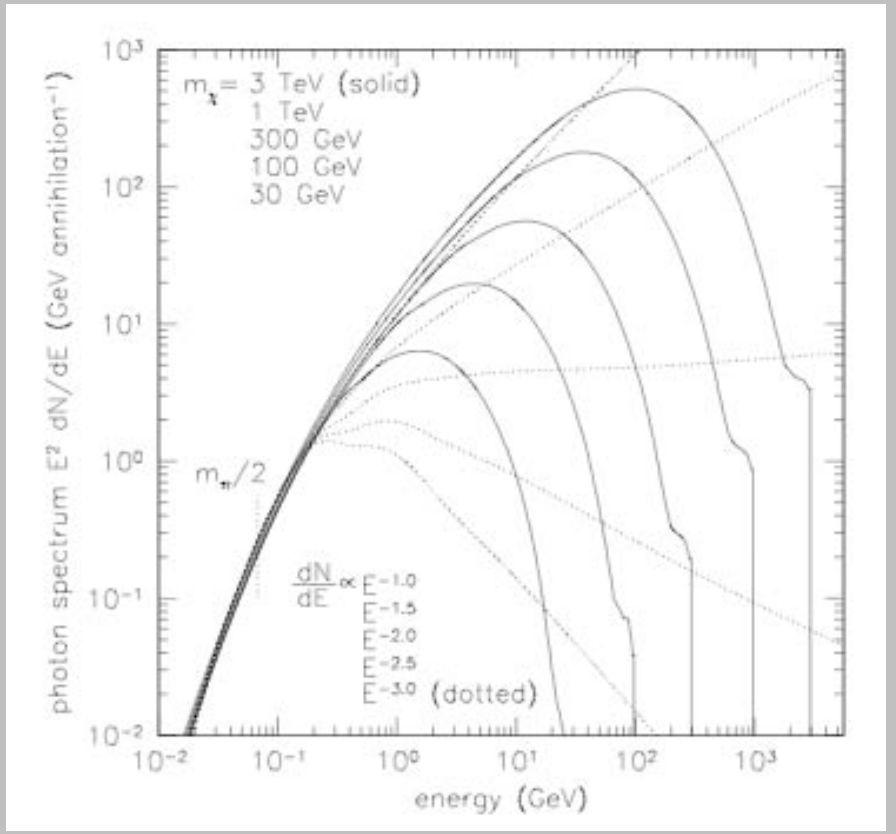
Possible tests/effects include indirect detection (decay products, e.g. local positron excess), direct detection (collisions in lab), and dynamics?

Details depend strongly on CDM specifics



Dark Matter Gamma-ray Spectrum:

+ Consider supersymmetric neutralinos (~ vanilla CDM WIMP candidate)
+ Most gammas via (non-rel.) quark-antiquark pairs ⇒ hadronization ⇒pions
+ Resulting pion bump at
  ~ $m_\chi/25$ ranges from
  1-100 GeV depending
  on WIMP mass
+ Sharp energy cutoff,
  so very different from
  e.g. emission from power-
  law cosmic-ray proton
  spectrum



Baltz, Taylor & Wai 2007 - spectrum from DarkSUSY/Pythia

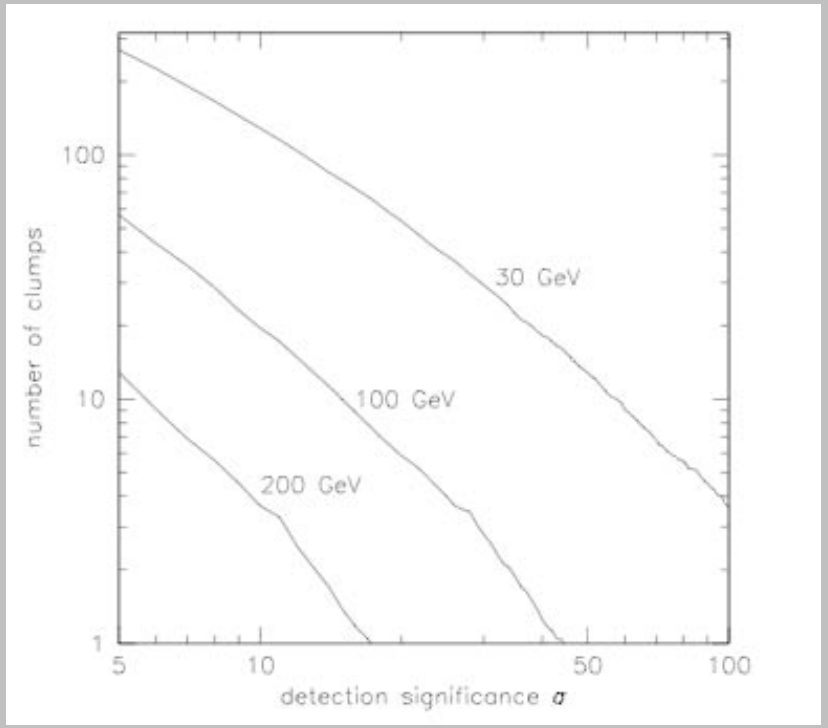
Number of Sources:

Brightness of local subhaloes depends on angular size (and thus distance) and on central density (and thus concentration and degree of stripping)

Scaling with mass/distance not trivial

Brightest sources are probably those that just fill the beam

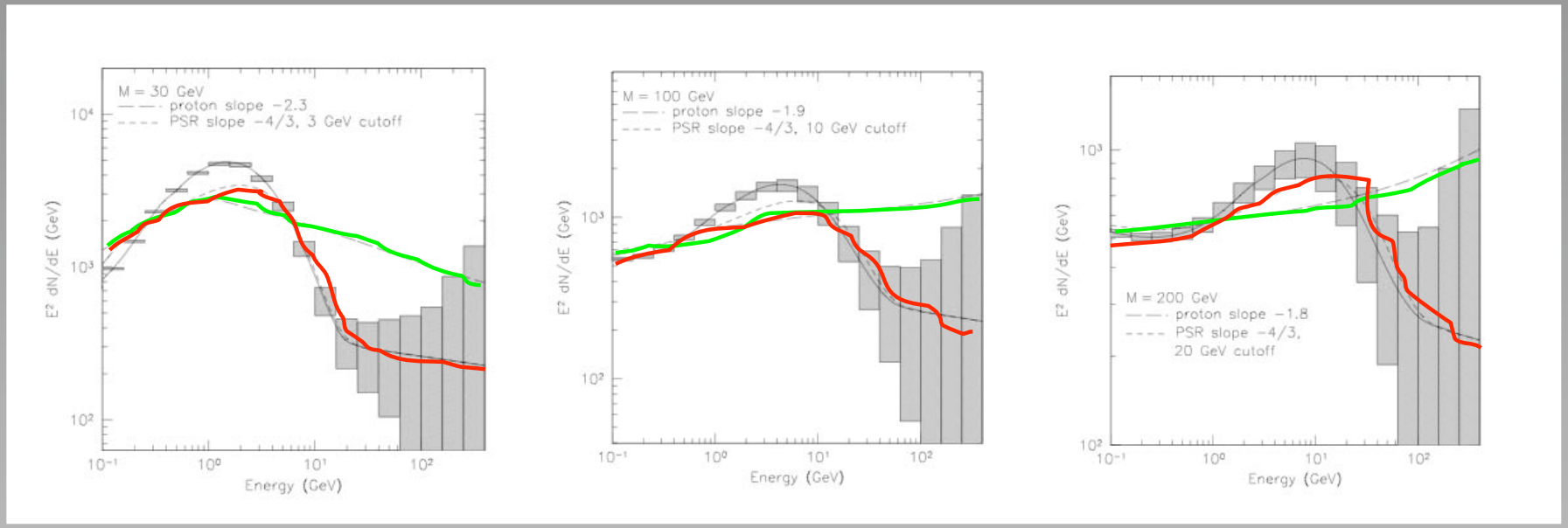
Possibly tens or hundreds of sources detectable by GLAST over 5-year mission?



Baltz, Taylor & Wai 2007

Spectral discrimination:

Consider 5-year exposure on brightest subhalo:



30 GeV 100 GeV 200 GeV

⇐ versus power-law proton source (GMC)

⇐ or versus pulsar with cutoff

Source Identification:

Source	Monoenergetic Quark Spectrum	Extended	Non-variable	High-latitude	No Counterparts
Subhaloes	✔	✔	✔	✔	✔
Molecular clouds	✖	✔	✔	✔	✖
Pulsars	~	✖	✖	~	✖
Plerions	✖	✔	✔	✖	✖
SNR	✖	✔	✔	✖	✖
Blazars	✖	✖	✖	✔	✖

Summary:

- The evidence for dark matter in general, and CDM in particular, is now overwhelming
- Generic arguments point to particles in the 100 GeV-few TeV mass range as likely candidates
- Spatial/spectral/variability tests would help identify local dark matter annihilation sources
- Even if LHC measures SSM masses, astrophysical info. is still crucial e.g. to rule out KK particles
- Is also the *only* source of information about cosmology over a wide range of scales/redshifts

Posters:

P18.1 - Conrad, Jan; GLAST sensitivity to cosmological dark matter annihiliations into gamma-rays·
P18.2 - Morselli, Aldo; Searching for point sources of dark matter annihilation with GLAST·
P18.3 - Moskalenko, Igor; Dark Matter in the Center of the Milky Way and the stars burning it·
P18.4 - Sanchez-Conde, Miguel; Angel Dark matter in draco: new considerations of the expected gamma flux·
P18.6 - Stark Schneebeli, Luisa Sabrina; Indirect dark matter search with the MAGIC telescope·
P18.8 - Bloom, Elliott D.; GLAST LAT WIMP line sensitivity estimates·

Dark matter talks tomorrow:

8.1 Dark Matter, Structure, and GLAST - M. Kuhlen (TBC)
8.2 Overview of GLAST Searches for Milky Way Dark Matter Substructure - L. Wai
8.3 Detecting Dark Matter via the Proper Motion of Microhalos - S. Koushiappas